Comparison of Farmers in the Agricultural Health Study to the 1992 and 1997 Censuses of Agriculture

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ABSTRACT. *Context:* The Agricultural Health Study (AHS) is a large, prospective cohort study in the states of Iowa and North Carolina that has been developed to better understand how pesticides and other agricultural exposures relate to the occurrence of cancer and other diseases.

Purpose: This report compares the characteristics of AHS farmers to the Census of Agriculture to evaluate the generalizability of AHS findings.

Methods: We restricted the AHS to private pesticide applicators who enrolled in Iowa (n = 31,065) and in North Carolina (n = 17,239) between 1993 and 1997, and who identified themselves as living or working on a farm. We compared their self-reported data with data from the 1992 and 1997 Censuses of Agriculture.

Findings: AHS farmers in Iowa are younger; live or work on larger farms; more frequently apply herbicides, insecticides, and fungicides; and are more likely to raise beef cattle and swine, and grow corn, soybeans, hay, and oats. AHS farmers in North Carolina are also younger, live or work on

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larger farms, more frequently reported growing crops commonly seen in the state, and are more frequent pesticide users. However, animals raised are similar to those in the North Carolina Census of Agriculture.

Conclusions: AHS farmers likely represent the higher end of pesticide usage in both states in part because AHS farmers have larger farms. Since the health effects of pesticides are best ascertained among pesticide users with the greatest exposure, the AHS cohort should prove to be a valuable resource for health effects research.

KEYWORDS. Farmers, census of agriculture, pesticides, agricultural health study

INTRODUCTION

The Agricultural Health Study (AHS) is a large, prospective cohort study that involves registered pesticide applicators and their spouses in the states of Iowa and North Carolina. The primary purpose of this study is to actively monitor a large number of these applicators and their spouses to evaluate the role of agricultural exposures, including pesticides, in the development of cancer and other chronic diseases.[1] The study is already being used to evaluate farm-related work injuries,[2-5] cooking practices,[6] pesticide-related visits to health care providers,[7,8] retinal degeneration,[9] wheeze,[10,11] cancer incidence,[12] and cancer as it relates to pesticide exposure.[13-15]

In Iowa, commercial pesticide applicators, private pesticide applicators (almost all farmers), and spouses of private pesticide applicators were recruited. Enrollment began in December 1993 and continued through November 1997. Most cohort members enrolled at testing and training sites for pesticide applicator certification. Both commercial and private applicators attended testing sites simultaneously, making it convenient to enroll both groups. Enrollment of North Carolina private applicators (mostly farmers) and their spouses occurred from January 1994 to September 1996 at training sites for pesticide applicator certification. Only private applicators attended these training sites, so commercial applicators were not enrolled in North Carolina.

Because of its size, detailed exposure assessment prior to onset of cancer and scope, the AHS may influence public health policy regarding a variety of agricultural exposures. It is, therefore, important to compare characteristics of AHS farmers to concurrent Censuses of Agriculture for Iowa (ICA) and North Carolina (NCCA) to evaluate external validity or generalizability of AHS findings.

MATERIALS AND METHODS

AHS data collected at enrollment in Iowa and North Carolina were used to compare with data from the 1992 and 1997 Censuses of Agriculture.[16-19] In Iowa, AHS enrollment occurred through training or testing sessions sponsored by the Iowa State University Cooperative Extension Service and the Iowa Department of Agriculture and Land Stewardship. In North Carolina, enrollment occurred as applicators sought certification from the North Carolina Department of Agriculture and Consumer Services by attending classes on the proper application of restricted-use pesticides sponsored by the North Carolina Cooperative Extension Service. Applicators enrolled in the study in both states by completing a 21-page, self-administered questionnaire. This questionnaire can be found at *www.aghealth.org/questionnaires.html.* Among eligible private applicators, 31,877 of 38,969 enrolled in the AHS in Iowa (81.8%) and 21,067 of 24,882 enrolled in North Carolina (84.7%). The 1992 and 1997 Censuses of Agriculture were used because they were closest to the time frame of the AHS questionnaire data collection. The AHS has been and continues to be reviewed and approved by institutional human subject review boards at the National Institutes of Health, the University

of Iowa, and Battelle Centers for Public Health Research and Evaluation.

The eligible AHS farmers included 31,065 Iowa private pesticide applicators and 17,239 North Carolina private applicators who responded "yes" to a question asking if the applicator lived or worked on a farm, the AHS definition of a farmer. The definition of a farm in the Census of Agriculture was "any place from which $1,000 or more of agricultural products were produced or sold, or normally would have been sold, during the census year."[16-19] The ICA identified 96,543 and the NCCA identified 51,854 eligible farms in 1992, each having one identified operator, also known as the senior partner or person in charge. Thus, the unit of analysis in the AHS was the farmer, whereas in the Census of Agriculture it was the farm.

Farmer-specific data from the AHS enrollment questionnaire on age, race, sex and three categories of pesticide use (i.e., insecticides, herbicides, and fungicides) were used to compare with data collected in the Census of Agriculture. Section 22 of the ICA and the NCCA includes all agricultural chemicals applied on the farm in 1992 and 1997 regardless of who applied the chemicals. In this section of these Censuses of Agriculture, agricultural chemicals were defined as sprays, dusts, granules, fumigants, etc., to control (1) insects on crops, including hay (the AHS category called insecticide); (2) weeds, grass, or brush in crops and pasture (the AHS category called herbicide); and (3) diseases in crops and orchards (blights, smuts, rusts, etc.) (the AHS category called fungicide). Census of Agriculture categories for nematodes and defoliants were not used because the AHS did not have comparable categories.

The second comparison concerned current major income-producing crops and animals currently raised on the farm. We used AHS questionnaire responses to the following categories: hogs/swine, beef cattle, dairy cattle, poultry, hay or alfalfa, oats, soybeans, field or seed corn, tobacco, wheat, peanuts, and other crops. We used Census of Agriculture responses in section 2 for crops and sections 13, 14, and 16 for animals. The animal questions referred to each livestock category by asking if the respondent or anyone else had any of that kind of livestock on the farm in 1992 or 1997. These questions did not discriminate between pet animals, animals raised for the family's food, and larger operations including intensive confinement production of poultry, swine, and beef cattle. The crop questions referred to any crops harvested from the farm in 1992 or 1997. In contrast with the AHS, no specification was made that crops or livestock had to be "major-income producing." Livestock categories from the Census of Agriculture were hogs or pigs, beef cows, milk cows, and poultry. Crop categories were hay or alfalfa, oats for grain, soybeans for beans, corn (field) for grain or seed, tobacco, wheat, peanuts, cotton, other small grains, sweet potatoes, and other potatoes.

The third comparison concerned acreage planted on the farm. The Censuses of Agriculture question (section 10), asked for number of acres used for cropland harvested in 1992 or 1997, whereas the AHS questionnaire asked about number of acres planted in the previous year.

From the 1992 and 1997 Censuses of Agriculture, each table provided a frequency where its denominator was the total number of farms supplying information and its numerator was the number of farms for which positive or "yes" responses were obtained. Corresponding frequencies were obtained from the AHS data for farmers. The frequencies, expressed as percentages, were then compared between the AHS and the two Censuses of Agriculture. Subjects in the AHS were excluded from the denominator if they did not respond "yes" to the question on whether they lived or worked on a farm. In the ICA, denominators of 96,543 total farms for the 1992 Census of Agriculture and 90,792 for the 1997 Census of Agriculture were reported for all variables reported herein. The corresponding denominators in North Carolina were 51,854 and 49,406. The Census of Agriculture used statistical estimation procedures to account for non-respondent farms, data editing and imputation for item non-response, and sample weighting and estimation for items obtained from only a sample of total

farms. These methods have been described in detail in Appendix C of the Census of Agriculture.[16-19] Statistical differences and 95% confidence intervals were calculated based on the normal approximation to the binomial distribution.[20] However, because of the large sample size, the resulting confidence intervals were narrow, ranging from 0.0 to 3.0 percentage points. Thus, we have elected to just present the point estimates and footnote the level of significance in the tables.

RESULTS

Demographically, the AHS farmers and agricultural populations from each state are composed primarily of white males (Table 1). Despite small percentages, females are three times more frequent in the ICA compared with the Iowa AHS farmers and about twice as frequent in the NCCA compared with North Carolina AHS farmers. The age distribution of Iowa AHS farmers is significantly younger than that of the ICA as 50.3% of Iowa AHS farmers are

TABLE 1. Demographic Characteristics of Agricultural Health Study (AHS) Farmers versus Census of Agriculture (CA)

State	Variable	1992 CA		AHS		1997 CA	
		No. of Farms	Percent	No. of Farmers*	Percent	No. of Farms	Percent
Iowa	Race						
	White	96,456	99.9	30,959	99.9	90,669	99.9
	Black	32	0.0	12	0.0	35	0.0
	Other	55	0.1	36	0.1	88	0.1
	Gender						
	Male	92,730	96.1	30,640	98.6‡	86,174	94.9
	Female	3,813	3.9	425	1.4‡	4,618	5.1
	Age						
	< 25	2,276	2.4	908	2.9	1,468	1.6
	25-34	13,100	13.6	4,829	15.6†	7,554	8.3
	35-44	22,200	23.0	9,901	31.9‡	20,841	23.0
	45-54	19,769	20.5	7,266	23.4	21,513	23.7
	55-64	20,857	21.6	5,662	18.2‡	19,200	21.1
	65-69	7,956	8.2	1,523	4.9‡	7,812	8.6
	70+	10,385	10.8	976	3.1‡	12,404	13.7
	Mean age (yrs.)	50.3		45.9		52.4	
North Carolina	Race						
	White	49,356	95.2	16,014	93.3‡	47,295	95.7
	Black	1,866	3.6	924	5.4	1,515	3.14
	Other	632	1.2	232	1.3	596	1.2
	Gender						
	Male	47,914	92.4	16,588	96.2‡	45,343	91.8
	Female	3,940	7.6	651	3.8‡	4,063	8.2
	Age						
	< 25	619	1.2	781	4.5‡	433	0.9
	25-34	3,726	7.2	2,324	13.5‡	2,938	6.0
	35-44	9,267	17.9	4,094	23.7‡	8,519	17.2
	45-54	11,803	22.7	4,001	23.2	12,370	25.0
	55-64	12,224	23.6	3,448	20.0‡	11,613	23.5
	65-69	5,440	10.5	1,301	7.6†	4,869	9.9
	70+	8,775	16.9	1,289	7.5‡	8,664	17.5
	Mean age (yrs.)	54.7		48.3		55.2	

* Total number of Iowa AHS farmers providing usable race information is 31,007, not 31,065, because of missing data. Missing data for North Carolina AHS farmers: race (n = 69) and age (n = 1).
† AHS percent is significantly different from corresponding 1992 and 1997 CA percents: $p < 0.05$.
‡ AHS percent is significantly different from corresponding 1992 and 1997 CA percents: $p < 0.01$.

TABLE 2. Demographic Characteristics of Agricultural Health Study (AHS) Farmers from Iowa and North Carolina versus United States Census of Agriculture (USCA)

Variable	1992 USCA		AHS (Iowa & North Carolina)		1997 USCA	
	No. of Farms	Percent	No. of Farmers*	Percent	No. of Farms	Percent
Race						
White	1,881,813	97.7	46,973	97.5	1,864,201	97.5
Black	18,816	1.0	936	1.9	18,451	1.0
Other	24,671	1.3	268	0.6	29,207	1.5
Gender						
Male	1,780,144	92.5	47,228	97.8‡	1,746,757	91.4
Female	145,156	7.5	1,076	2.2‡	165,102	8.6
Age						
< 25	27,906	1.5	1,689	3.5‡	20,850	1.1
25-34	178,826	9.3	7,153	14.8‡	128,455	6.7
35-44	381,746	19.8	13,995	29.0‡	371,442	19.4
45-54	429,333	22.3	11,267	23.3†	466,729	24.4
55-64	429,839	22.3	9,110	18.9‡	427,354	22.4
65-69	188,165	9.8	2,824	5.8‡	179,858	9.4
70+	289,485	15.0	2,265	4.7‡	317,171	16.6
Mean age (yrs.)	53.3		46.8		54.3	

* Missing data for AHS farmers: race (n = 127) and age (n = 1).
† AHS percent is significantly different from corresponding 1992 and 1997 USCA percents: $p < 0.05$.
‡ AHS percent is significantly different from corresponding 1992 and 1997 USCA percents: $p < 0.01$.

under 45 years of age compared with only 39% and 32.9% of the ICA population in 1992 and 1997, respectively. Mean ages are 45.9 years for the Iowa AHS farmers and 50.3 and 52.4 years for the 1992 and 1997 ICA populations. In North Carolina, 41.8% of the AHS farmers are under 45 years of age compared with 26.3% and 24.1% of the NCCA populations in 1992 and 1997, respectively. The mean age in the NCCA was 54.7 years in 1992 and 55.2 years in 1997, while it was 48.3 years for the North Carolina AHS farmers.

When all AHS farmers from Iowa and North Carolina are compared to the descriptive statistics of all U.S. Census of Agriculture (USCA) farmers in 1992 and 1997, these same observations hold (Table 2). The race distribution of AHS farmers is similar to that of USCA farmers as white farmers predominate across all groups although there is a small but higher percentage of black farmers in the AHS. There is a smaller proportion of female farmers in the AHS, 2.2% versus 7.5% and 8.6% in the 1992 and 1997 USCA. AHS farmers are younger than USCA farmers with an average age of 46.8 years compared to 53.3 years and 54.3 years of age as reported in the 1992 and 1997 USCA, respectively. In the AHS population 47.3% are younger than 45 years of age. This age group comprises only 30.6% in the 1992 USCA and decreases to 27.2% in the 1997 USCA.

In Iowa, field/seed corn and soybeans were reported as the two most frequent crops in both populations (Table 3). The Iowa AHS farmers reported higher frequencies of field or seed corn, soybeans, hay or alfalfa, and oats compared with the ICA. Hogs/swine and beef cattle were reported as the two most commonly raised livestock in both populations. The frequencies for hogs/swine, beef cattle, and milk cows were higher for Iowa AHS farmers relative to the ICA population. Sheep and poultry were less frequently reported in both populations. The distribution of the number of farm acres planted (AHS) or harvested (ICA) showed Iowa AHS farmers as much more likely to plant 500 or more acres. The use of herbicides, insecticides, and fungicides was also more frequent among Iowa AHS farmers as compared with the ICA population. In both populations, herbi-

TABLE 3. Farm Characteristics of Iowa Agricultural Health Study (AHS) Farmers versus Iowa Census of Agriculture (ICA)

Farm Characteristic	1992 ICA (n = 96,543)		AHS (n = 31,065)		1997 ICA (n = 90,792)	
	No. of Farms	Percent	No. of Farmers*	Percent	No. of Farms	Percent
Crops						
Field/seed corn	82,331	85.3	29,759	95.8‡	70,265	77.4
Soybeans	59,945	62.0	27,053	87.1‡	56,436	62.2
Hay/alfalfa	44,768	43.6	15,053	48.5‡	37,711	41.5
Oats	17,854	18.5	8,994	29.0‡	10,823	11.9
Wheat	970	1.0	738	2.4	719	0.8
Livestock						
Hogs/swine	31,790	32.9	14,650	47.2‡	17,243	19.0
Beef cattle	29,987	31.0	14,389	46.3‡	27,452	30.2
Milk cows	5,878	6.0	2,251	7.3	4,208	4.6
Sheep	6,760	7.0	1,568	5.1	4,431	4.9
Poultry	3,390	3.5	777	2.5	2,655	2.9
Farm Acres Planted (AHS)* or Harvested (ICA)						
None	12,534	13.0	273	0.9‡	15,841	17.4
1-49	16,200	16.8	601	2.0‡	15,222	16.8
50-199	28,481	29.5	4,783	15.8‡	23,346	25.7
200-499	25,995	26.9	10,542	34.8‡	21,216	23.4
500-999	10,736	11.1	8,745	28.8‡	11,290	12.4
1000+	2,597	2.7	5,382	17.7‡	3,877	4.3
Pesticide Use						
Herbicides	59,568	61.7	26,244	84.5‡	53,909	59.4
Insecticides	37,097	38.4	18,035	58.1‡	24,957	27.5
Fungicides	863	0.9	908	2.9	1,122	1.2

* Total number of AHS farmers providing usable farm acre information is 30,326 not 31,065, primarily because of missing data.
† AHS percent is significantly different from corresponding 1992 and 1997 ICA percents: $p < 0.05$.
‡ AHS percent is significantly different from corresponding 1992 and 1997 ICA percents: $p < 0.01$.

cides were reported as most frequently used followed by insecticides. Use of fungicides was infrequently reported in Iowa.

A wider variety of crops were reported in North Carolina than Iowa, reflecting the greater agricultural diversity of this state (Table 4). Comparing North Carolina AHS farmers and the NCCA, the top 5 crops are the same, although the rank order does differ (Table 4). North Carolina AHS farmers reported higher frequencies of tobacco, soybeans, field/ seed corn, wheat, peanuts, cotton, oats, other small grains, sweet potatoes, and other potatoes. Only hay/alfalfa had a higher frequency in the NCCA. The rank order of type of livestock also slightly differed between North Carolina AHS farmers and the NCCA, however, beef cattle were consistently the most frequently reported. North Carolina AHS farmers also were more likely to report planting 500 or more acres (19.5% versus 3.5%) and much less frequently reported planting 1 to 49 acres (35.9% versus 56.7%). The reported use of herbicides, insecticides, and fungicides was higher for the North Carolina AHS farmers than in the NCCA.

Compared to the Census of Agriculture of the entire U.S. (USCA), AHS farmers in Iowa and North Carolina are more likely to grow field/seed corn, soybeans, oats, tobacco, cotton, peanuts, and potatoes including sweet potatoes and are more likely to raise hogs/swine (Table 5). They are more similar to the USCA regarding the frequencies for wheat, beef cattle, milk cows, and poultry and less frequently grow hay/alfalfa. Despite these differences, AHS farmers grow crops and raise livestock

TABLE 4. Characteristics of North Carolina Agricultural Health Study (AHS) Farmers versus North Carolina Census of Agriculture (NCCA)

Farm Characteristic	1992 NCCA (n = 51,854)		AHS (n = 17,239)		1997 NCCA (n = 49,406)	
	No. of Farms	Percent	No. of Farmers	Percent	No. of Farms	Percent
Crops						
Tobacco	17,625	34.0	8,141	47.2‡	12,095	24.5
Soybeans	13,080	25.2	7,968	46.2‡	9,933	20.1
Field/seed corn	14,779	28.5	7,886	45.8‡	10,074	20.4
Wheat	6,883	13.3	5,199	30.2‡	5,949	12.0
Hay/alfalfa	18,268	35.2	4,176	24.2‡	19,761	40.0
Cotton	2,035	3.9	2,436	14.1‡	2,320	4.7
Peanuts	2,371	4.6	2,197	12.7‡	1,765	3.6
Oats	1,993	3.8	1,542	8.9‡	1,059	2.1
Potatoes other than sweet potatoes	857	1.7	1,583	9.2‡	459	0.9
Sweet potatoes	954	1.8	1,174	6.8‡	512	1.0
Livestock						
Beef cattle	19,531	37.7	4,996	29.0‡	19,616	39.7
Hogs/swine	4,311	8.3	1,832	10.6†	2,986	6.0
Poultry	4,546	8.1	1,168	6.8	4,532	9.2
Milk cows	1,552	3.0	629	3.7	1,092	2.2
Farm Acres Planted (AHS)* or Harvested (NCCA)						
None	9,719	18.7	1,015	6.4‡	11,165	22.6
1-49	29,394	56.7	5,636	35.9‡	26,277	53.2
50-199	7,989	15.4	3,493	22.3‡	7,289	14.8
200-499	2,932	5.7	2,511	16.0‡	2,628	5.3
500-999	1,195	2.3	1,578	10.1‡	1,234	2.5
1000+	625	1.2	1,456	9.3‡	813	1.6
Pesticide Use						
Herbicides	18,064	34.8	12,111	70.3‡	16,194	32.8
Insecticides	18,367	35.4	11,109	64.4‡	14,391	29.1
Fungicides	6,379	12.3	5,225	30.3‡	5,525	11.2

* Total number of AHS farmers providing usable farm acre information is 17,238, not 17,239, because of missing data.
† AHS percent is significantly different from corresponding 1992 and 1997 NCCA percents: $p < 0.05$.
‡ AHS percent is significantly different from corresponding 1992 and 1997 NCCA percents: $p < 0.01$.

that are very commonly seen in United States agriculture.

DISCUSSION

The racial distribution was similar between the AHS subjects and the Censuses of Agriculture in both states, and males greatly outnumbered females. Despite accounting for small percentages, females were three times more frequent in the ICA compared with Iowa AHS farmers and about twice as frequent in the NCCA compared with North Carolina AHS farmers. It is possible that female farmers own smaller farms, are widowed and lease out their farmland, or are organic farmers and therefore are less likely to have pesticide applicator certification.

In Iowa, AHS farmers were younger; living or working on larger farms; more frequently applying herbicides, insecticides, and fungicides; more likely to raise beef cattle and hogs/ swine; and more likely to grow corn, soybeans, hay, and oats. In North Carolina, AHS farmers were also younger; living or working on larger farms; more likely to use pesticides; more frequently reporting

TABLE 5. Characteristics of Iowa and North Carolina Agricultural Health Study (AHS) Farmers versus United States Census of Agriculture (USCA)

Farm Characteristic	1992 USCA (n = 1,925,300)		AHS (n = 48,304)		1997 USCA (n = 1,911,859)	
	No. of Farms	Percent	No. of Farmers	Percent	No. of Farms	Percent
Crops						
Field/seed corn	503,935	26.2	37,645	77.9‡	430,711	22.5
Soybeans	381,000	19.8	35,021	72.5‡	354,692	18.6
Hay/alfalfa	905,296	47.0	19,229	39.8‡	888,597	46.5
Oats	140,755	7.3	10,536	21.8‡	89,606	4.7
Tobacco	124,270	6.5	8,143	16.9‡	89,706	4.7
Wheat	292,464	15.2	5,937	12.3	243,568	12.7
Cotton	34,812	1.8	2,437	5.1‡	31,493	1.6
Potatoes other than sweet potatoes	14,502	0.8	2,207	4.6‡	10,523	0.6
Peanuts	16,194	0.8	2,203	4.6‡	12,221	0.6
Sweet potatoes	2,700	0.1	1,286	2.7‡	1,770	0.1
Livestock						
Beef cattle	803,241	41.7	19,385	40.1‡	804,595	42.1
Hogs/swine	191,347	9.9	16,482	34.1‡	109,754	5.7
Milk cows	155,339	8.1	2,880	6.0	116,874	6.1
Poultry	119,394	6.2	1,945	4.0‡	109,795	5.7
Farm Acres Planted (AHS) * or Harvested (USCA)						
None	433,514	22.5	1,288	2.8‡	501,253	26.2
1-49	702,678	36.5	6,237	13.5‡	674,025	35.3
50-199	405,258	21.0	8,276	18.0†	371,776	19.4
200-499	216,110	11.2	13,053	28.4‡	189,243	9.9
500-999	110,003	5.7	10,323	22.4‡	105,079	5.5
1000+	57,737	3.0	6,838	14.9‡	70,483	3.7
Pesticide Use						
Herbicides	757,340	39.3	46,835	97.0‡	685,056	35.8
Insecticides	479,831	24.9	44,571	92.4‡	366,127	19.2
Fungicides	120,965	6.3	17,554	36.4‡	112,513	5.9

* Total number of AHS farmers providing usable farm acre information is 46,015, not 48,304, primarily because of missing data.
† AHS percent is significantly different from corresponding 1992 and 1997 USCA percents: $p < 0.05$.
‡ AHS percent is significantly different from corresponding 1992 and 1997 USCA percents: $p < 0.01$.

different crops with the exception of hay/alfalfa; and slightly more likely to raise hogs/swine, but less likely to raise beef cattle.

Since AHS enrollment occurred between 1992 and 1997, AHS enrollment data were compared with the closest available data from the Census of Agriculture in spite of varying definitions. For example, pesticide application as defined in the Census of Agriculture was farm-specific and not farmer-specific as in the AHS. In both states, a majority of the farms are family owned. It may be that the oldest person on the farm is listed as the operator in the Census of Agriculture, but the family member who is most active on the farm may be the one to obtain pesticide certification. We defined crop and livestock from the AHS based on a question asking respondents to check all current major income-producing crops and livestock. From the Census of Agriculture, any crops harvested or any livestock on the farm in 1992 and 1997 were included. Similarly, acres planted in the AHS may differ from acres harvested, as defined in the Census of Agriculture. In addition, in both states for the 1,000+ category of acres planted or harvested, there were more

AHS farmers than recorded in the Census of Agriculture. This could also have resulted from AHS farmers reporting acres planted from several farms combined as compared to reporting each of these individually to the Census of Agriculture. These differences could account for over- or under-reporting in comparing these populations, and have led us to emphasize trends and overall results.

Differences between the AHS and Census of Agriculture populations may also reflect AHS enrollment occurring between the 1992 and 1997 Censuses of Agriculture. The nation's farm population has been shrinking as a percentage of the total population since 1920 when the farm population was 30.2%[21] to 1990 when the farm population was 1.6%.[22] The average farm size in Iowa increased 5.5% from 325 acres to 343 acres between the 1992 ICA and the 1997 ICA. During the same time period, the number of farms in Iowa decreased 6% from 96,543[16] to 90,792 farms.[18] Certified private applicators in Iowa also declined by 6,200 or 13.5% during this period. Trends in North Carolina agriculture have paralleled those in Iowa, with the number of farms decreasing from 51,854 in 1992 to 49,406 in 1997; meanwhile, the average size increased from 172 acres to 185.[17,19] These changes indicate a continuing trend toward increasing farm size and a decreasing number of farms and farmers in both states.

Of the 31,877 private applicators enrolling in the AHS in Iowa, 97.5% responded "yes" to the question about living or working on a farm. In North Carolina, of the 21,067 enrolled in the AHS, 81.8% responded "yes" to the question about living or working on a farm. We have found that holding a nonfarm job was more frequently reported by North Carolina private applicators (74%) than Iowa private applicators (59%).[23] This may correspond to the smaller farm acreages found in North Carolina and to lower farm income. A small fee is paid to obtain and renew pesticide applicator certification in both states. The certification entitles these applicators to purchase restricted-use pesticides to apply to their farmland. Since no certification is needed to purchase or apply general use pesticides, some farmers may choose to use only these products, thus avoiding the need for certification. Other farmers may choose to hire custom applicators to apply restricted-use pesticides to their farmland. We believe that farmers with small farm operations are more likely to use these alternatives, since pesticide application equipment is likely to be cost-prohibitive for small producers. As a result, these small farms would tend to be less represented in the AHS population.

CONCLUSIONS

Compared with the Census of Agriculture data, in both Iowa and North Carolina AHS farmers appear to represent larger farms that more frequently report use of pesticides. We conclude therefore that AHS farmers likely represent the higher end of pesticide usage in the agricultural populations of both states as well as the United States as a whole. Despite these differences, however, there is large overlap with agricultural activities between the AHS cohort and the general farm population in each state. Thus, the cohort does represent the farm population to a considerable degree in Iowa, North Carolina, and the United States. Observations made within the cohort will likely have external validity. Second, since the cohort generally represents a group that is more highly exposed to pesticides, its power to ascertain deleterious effects of these chemicals is enhanced. Although dosage is important to health effects and thresholds may exist where high exposures may not be generalizable to low exposures, we anticipate that the health effects of specific agricultural exposures including pesticides will have generalizability to the general farming population and others who share these exposures, because we have been finding both low and high doses reported for specific exposures given the large size of the AHS cohort.

AUTHORS NOTE

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